ANSWERS: Atomic and Ionic Radii

1) The K^+ ion has a smaller radius than the K atom, as the ion has lost an electron from the valence/outer energy level, and therefore has fewer shells. This results in greater attraction between the nucleus and the valence electrons, as the outer electrons are now closer to the nucleus. There is less repulsion between the remaining electrons. Both species have the same number of protons / amount of nuclear charge.

2) Cl^- has an extra electron in its outermost/same energy level. This causes increased repulsion between electrons in the valence shell, so the electrons move further apart. This makes Cl^- bigger than Cl. Both Cl and Cl^- have the same number of protons/attractive force of the nucleus remains the same.

3) Both Cl and Cl^- have their valence electrons in the same energy level but Cl^- has one more electron, which causes greater electron – electron repulsion. Hence Cl^- has a larger radius. Na^+ has one less energy level than Na. Hence Na^+ has a smaller radius.

4) Ge = 123 pm
Cu = 128 pm
Cu^+ = 77 pm

Both atoms have the same number of electron shells / energy levels / shielding of outer electrons by inner electrons / valence electrons in same energy level. Ge, however, has a greater nuclear charge / number of protons, compared to Cu, so there is a stronger attraction for the **valence electrons**, bringing them in closer, resulting in a smaller radius.

Cu^+ has fewer electron shells than the Cu/Ge atoms (only 3 vs 4) and hence the electrons are closer to the nucleus meaning it is the smallest of the three particles.

Cu> Ge > Cu^+

5) Al has the larger radius.
Al^{3+} has lost 3 electrons / valence shell.

This means that there is one less energy level than in Al.

The remaining electrons are drawn closer by nuclear charge / nuclear attraction greater causing smaller size.

6) Ca = 197 pm
Ca^{2+} = 99 pm
Mn = 137 pm
Both Ca and Mn the same number of electron shells / energy levels / shielding of outer e's by inner e's / valence e's in same energy level (same orbital 4s).
But Mn has a greater nuclear charge / no of protons so there is a stronger attraction for the valence electrons, bringing them in closer, resulting in a smaller radius.

Ca > Ca^{2+} or Mn > Ca^{2+}
Ca^{2+} is smallest because it has lost electrons from an entire valence shell, so the electrons are in only 3 shells instead of 4 / less shells.

7) Br^- > Br added electron increases electron – electron repulsion, increasing size of the electron cloud so Br^- larger
Br < I I outer shell electron are in an extra energy level / shell further from the nucleus and shielding of <u>outer</u> electrons so I larger
Br^- > I increase in repulsion when e^- added to form the ion, has greater influence than the energy level difference for the valence e^-
So Br- larger.

8) $H^+ < H < H^-$
because H^+ has no electron / has lost a shell / has lost an electron / is a bare proton

because H^- has more electrons: causing electron repulsions.

9) Br has greater nuclear charge / no. of protons
But same number of shells / energy levels
Br has greater effective nuclear charge (ENC)
Causing stronger attraction to the electrons.

10) $r(K^+) < r(K)$, K^+ has: 1 fewer shell/subshell/energy level
$r(P^{3-}) > r(P)$ P^{3-} has: more valence e^- – causing greater $e^- – e^-$ repulsion

11) Cl^- is larger or Ca^{2+} smaller.
Both have same number of shells or electron arrangement. Ca^{2+} has more protons or nuclear charge is greater, so the electrostatic attraction between the valence electrons and the nucleus is stronger, making Ca^{2+} smaller.